PB 207 166

THE EFFECTS OF POLLUTION CONTROL ON THE NONFERROUS METALS INDUSTRIES

ALUMINUM

Part III

The Economic Impact of Pollution Abatement on the Industry

Submitted to
The Council on Environmental Quality
Executive Office of the President
Washington, D.C.

CRA

CHARLES RIVER ASSOCIATES INCORPORATED · CAMBRIDGE, MASSACHUSETTS

December 1971

37

CRA

CHARLES RIVER ASSOCIATES INCORPORATED

THE ECONOMIC EFFECTS OF POLLUTION CONTROLS ON THE NONFERROUS METALS INDUSTRY: ALUMINUM

Prepared for
the Council on Environmental Quality

Prepared by
Charles River Associates Incorporated
16 Garden Street
Cambridge, Massachusetts 02138

December 1971

TABLE OF CONTENTS

Preface. i

Part I

Chapter 1 -- INTRODUCTION AND EXECUTIVE SUMMARY . . 1
Overview of the Aluminum Market. 1
Technology of Production 3
Demand for Aluminum. 5
Industrial Organization. 8
Aluminum Prices. 10
Government Policies. 11
The Aluminum Industry in the United States 13
Effects of Pollution Controls on the Aluminum Market 14

Part II

Chapter 2 -- TRENDS IN SUPPLY AND TECHNOLOGY OF ALUMINUM PRODUCTION 21
Bauxite. 21
Bauxite Reserves 23
Bauxite Mining 24
Alumina. 27
Aluminum 30
Smelting Costs 33
Location of Aluminum Smelters. 34
Short- and Long-Run Cost Functions 35
Costs of Integrated Aluminum Production. 36
Foreseeable Trends in Production Technology. . . . 39

Chapter 3 -- CONSUMPTION OF ALUMINUM. 42
U.S. Shipments of Mill Products. 45

TABLE OF CONTENTS (Continued)

Foreign Consumption by End Use. 47
U.S. Consumption by End Use 47
Major Aluminum Markets. 49
Building and Construction 49
Transportation. 52
Automobiles 52
Aircraft. 54
Commercial Vehicles 55
Electrical and Communications Equipment 56
Containers and Packaging. 58
Consumer Durables 59
Machinery and Equipment 60
Defense 61
Other Applications. 63
Substitution and Outlook for Aluminum Consumption . 63

Chapter 4 -- STRUCTURE OF THE ALUMINUM INDUSTRY. . . 67
Current Structure of the Industry 68
Current Trends in Industry Concentration. 74

Chapter 5 -- PRICES IN THE ALUMINUM INDUSTRY 77
Prices of Aluminum Ingot. 78
Prices of Aluminum in Different Markets 84
Prices of Fabricated Products 86
A General Model of Price Determination in the Aluminum Market. 91

Chapter 6 -- GOVERNMENT POLICIES 96
Aluminum Stockpiling Program. 96
Commercial Policies and Barriers to Trade 98
The Effects of the Wage-Price Freeze on the Aluminum Market 100

TABLE OF CONTENTS (Continued)

Chapter 7 -- THE ALUMINUM INDUSTRY IN THE UNITED STATES 101

Bauxite. 101

Alumina. 103

Aluminum 105

Balance of Payments in Aluminum. 111

Financial Data of Aluminum Companies 112

Part III

Chapter 8 -- THE ECONOMIC EFFECTS OF POLLUTION CONTROLS ON THE ALUMINUM MARKET. . . . 118

Cost Estimates 118

Probable Trends in the Aluminum Market in the Absence of Pollution Controls 125

Effects of Pollution Abatement Costs on the Aluminum Market 127

Effects if Controls are Imposed Only on the Aluminum Market. 128

Effects If Controls are Also Imposed on the Copper Industry 132

Effects of Controls If Power Generation is Also Controlled. 134

Effects of Controls If Other Industries in Addition to Copper are Also Controlled. . . . 135

Effects of Controls on U.S. Aluminum Production. 136

Effects of Control Costs on U.S. Alumina and Bauxite Production 138

Effects of Controls on Employment. 139

The Net Costs to Producers of the Controls . . . 140

The Regional Impact of the Controls. 141

The Inputs of the Controls on Supplier and Consumer Industries 142

TABLE OF CONTENTS (Continued)

The Effects of the Controls On
the U.S. Balance of Payments 143

The Effects of the Timing and Level of
the Control Costs on the Aluminum Market 144

The Effects of the 10 Percent Surcharge or
Equivalent Currency Revaluation on the Results . . 145

PREFACE

This report on the economic effects of pollution controls on the aluminum industry has been organized into three parts comprised of eight chapters. The three parts can be read separately or in conjunction with one another. Part I summarizes the contents of the succeeding two parts, providing a broad profile of the aluminum industry and outlining the economic effects of pollution controls on the industry. The important points and conclusions of the full report are contained in the first part, with greater detail and analysis in the follcwing two parts.

Part II comprises separate chapters on:

- Trends in supply and the technology of production
- Consumption
- Structure of the industry
- Prices
- Government policies
- The aluminum industry in the United States

Part III is our detailed analysis of the economic effects of imposing pollution controls on the aluminum industry.

Much of the information contained here was first published in Charles River Associates Incorporated, *An Economic Analysis of the Aluminum Industry* (Cambridge, Mass., March 1971), which we prepared under contract with the General Services Administration. Data presented in this report if not otherwise attributed is taken from our GSA report.

PART III

Chapter 8
THE ECONOMIC EFFECTS OF POLLUTION CONTROLS ON THE ALUMINUM MARKET

Cost Estimates

Both alumina and aluminum production create air pollution problems, while only alumina production is responsible for significant water pollution.

Alumina production generates both waste gas and dust dispersion. According to one source, the production of a ton of alumina generates 3,000 cubic meters of waste gas; the dust content of the gas is 300-400 grams per cubic meter.[1]

Aluminum production generates CO_2, carbon dust, some alumina dust, and particulate and gaseous fluorides. The production of a ton of aluminum generates 2000-3000 cubic meters of waste gas; each cubic meter of this gas contains 0.08-0.12 grams of dust and 0.040 grams of fluorine.[2] "Aluminum plants using carbon anodes which have been baked before mounting in cells may have dry dust collectors to remove particulates from collected effluents, scrubbers for removal of gaseous

---

[1]Kenneth W. Nelson, "Nonferrous Metallurgical Operations", *Air Pollution*, Vol. III, 2nd Edition, Arthur Stern, ed., Academic Press, New York, 1968, p. 187.

[2]*Ibid.*

fluorides, and stacks for final dispersion of scrubbed gases. Plants employing the Soderberg method of forming and baking carbon electrodes in place on the cells may omit dry collection and scrub all effluents directly."[1] In addition, some aluminum plants have installed scrubbers to wash the air leaving the roof monitors.

Table 8-1 presents data provided by the Council on Environmental Quality on the costs that would have to be incurred by the aluminum smelters to control gaseous sulfide emissions and to meet the particulate emission rate limitations published on April 7, 1971.[2] It was estimated that the true costs could be 25 percent lower or higher than these estimates.

The costs in Table 8-1 are calculated using several key assumptions. In particular, it is assumed that no additional air pollution abatement expenditures will be necessary at alumina plants, that capacity will grow at 5.25 percent per year, that production will grow at 5.8 percent per year, and that all control equipment would have to be replaced.

These assumptions are useful as first-order estimates of abatement costs. However, for the purposes of future research there are several areas in which the cost estimates can be tightened up. First, there apparently is a potential air pollution problem at alumina plants. These plants emit both particulate matter and gaseous fluorides. Second, U.S. consumption of aluminum will probably grow somewhat faster than .8 percent per year in the next five

---

[1] *Ibid.*

[2] pp. 15495-19496 of *Federal Register*, April 7, 1971.

Table 8-1
COST OF CONTROLLING PARTICULATE EMISSIONS
AT ALUMINUM SMELTERS
(Millions of August 1971 Dollars)

Investment Outlays	1972	1973	1974	1975	1976
Existing facilities	35.7	71.3	245.5	258.2	71.3
New facilities	42.0	42.0	42.0	42.0	42.0
Total	77.7	113.3	291.5	327.2	113.3
Annual Costs					
Operating and maintenance	8.6	21.0	53.1	89.1	101.5
Interest	4.6	15.8	46.2	69.0	92.3
Depreciation	3.2	9.7	32.1	57.7	64.2
Total	16.4	44.5	133.4	229.8	258.0
"Total" Costs					
Total cash costs[1]	90.0	148.1	390.8	499.3	307.1
Total deductions[2]	86.3	134.3	344.6	416.3	214.8

[1] Investment costs plus annual costs minus depreciation.

[2] Total cash costs minus interest.

SOURCE: Council on Environmental Quality.

NOTE: The following assumptions were made in deriving the cost estimates:

1. Only particulate fluorides are controlled.
2. All control equipment will have to be replaced.
3. The interest rate is 10 percent.
4. Capacity will grow at 5.25 percent per year.
5. Production will grow at 5.8 percent per year.
6. The depreciation rate is 7 percent.
7. There is no down time.
8. Costs of controlling power emmission and costs of auxiliary facilities may increase costs by 25 percent.

years, so the assumed growth rate for U.S. production is somewhat low. On the other hand, there is currently substantial over-capacity at domestic smelters, so the assumed growth rate for capacity is probably somewhat high. In fact, it is possible that new capacity may be located abroad as a result of the controls. The remaining assumptions underlying the cost estimates can only be analyzed by examining detailed information on each individual aluminum facility.

The most relevant abatement cost figures for the aluminum industry are the long-run annual costs per pound of aluminum. The initial capital outlays for abatement of about $713 million over the 1972 to 1976 period are huge in absolute terms, and an expenditure of this magnitude by the industry will be quite painful. There is little doubt, however, that the aluminum producers have the financial resources to raise such capital sums. For that matter, much of the increased costs of production will be passed on to consumers in the long run.

The annual cost of abatement, defined to equal operating and maintenance costs of abatement equipment, interest, and depreciation, represents the true long-run costs to producers of installing and maintaining a given level of abatement facilities. It is this cost that producers will have to recover on each pound of ingot if producers were to be indifferent to the abatement regulations.

It should be noted that the impact of these expenditures on the producers' net income will be smaller than normal expenditures as a result of special

tax incentives. First, the Tax Reform Act of 1969 allows firms to amortize pollution control equipment over 5 years instead of the usual 14 years. Second, there is currently pending in Congress a proposal for an investment tax credit providing a tax reduction amounting to 7 percent of the cost of an asset. The limitation on this tax reduction are that:

1) the credit cannot exceed total tax liability;
2) the allowable credit maximum is $25,000 plus 50% of the tax liability in excess of $25,000; and
3) the credit can be carried back three years and forward seven years.

As shown below the annual costs per pound of air pollution abatement reach a maximum of $0.023 by 1978:

	Assumed U.S. Production (Million lbs.)	Total "Annual"[1] Abatement Cost ($ Million)	Abatement Costs/Pound
1970	7,952	-	-
1971	8,413	-	-
1972	8,901	$ 16.4	$ 0.002
1973	9,417	44.5	0.005
1974	9,963	133.4	0.013
1975	10,540	229.8	0.022
1976	11,151	258.0	0.023

[1]Annual costs equal operation and maintenance, interest, and depreciation.

It is assumed that under reasonable assumptions these abatement costs could be 25 percent greater or lower than stated above, which gives the following range of estimated annual abatement costs (dollars per pound):

	Low	Middle	High
1972	$ 0.002	$ 0.002	$ 0.003
1973	0.004	0.005	0.006
1974	0.011	0.013	0.017
1975	0.017	0.022	0.028
1976	0.017	0.023	0.029

Table 8-2 presents the estimated costs of controlling water pollution in the aluminum industry. These costs are incurred primarily at alumina plants. A reasonable range for the true maximum costs may be between 25 percent below and 30 percent above these estimates. With the base cost estimates the annual costs of water pollution abatement reach a maximum of about $0.003 per pound of aluminum in 1976:

	U.S. Production (million Pounds)	Total Amount Abatement Cost ($ million)	Middle Estimate of Abatement Cost Per Pound	Low Cost Estimate	High Cost Estimate
1972	8,901	5.58	$ 0.001	$ 0.000	$ 0.001
1973	9,417	11.34	0.001	0.001	0.002
1974	9,903	17.22	0.002	0.001	0.002
1975	10,540	23.25	0.002	0.002	0.003
1976	11,151	29.44	0.003	0.002	0.003

It should be noted that the expenditures are subject to the same tax incentives as are expenditures on control of air pollution.

Table 8-2
COSTS OF WATER POLLUTION ABATEMENT
AT U.S. ALUMINA FACILITIES
(Millions of August 1971 Dollars)

Investment Outlays	1972	1973	1974	1975	1976
Existing facilities	26.42	28.03	29.68	31.37	33.11
New facilities	12.50	13.23	14.03	14.84	15.72
Total	38.92	41.26	43.71	46.21	48.83
Annual Costs					
Operating and maintenance	.87	1.78	2.70	3.66	4.63
Interest	3.14	6.38	9.68	13.06	16.54
Depreciation	1.57	3.18	4.84	6.53	8.27
Total	5.58	11.34	17.22	23.25	29.44
"Total" Costs					
Total cash costs[1]	42.93	49.42	56.09	62.93	70.00
Total Direct Costs[2]	39.79	43.04	46.41	49.87	53.46

[1]Investment costs plus annual costs minus depreciation.

[2]Total cash costs minus interest.

SOURCE: Council on Environmental Quality.

NOTE: The following assumptions were made in deriving these cost estimates:

1. In 1971 the industry had invested approximately $117 million (in August 1971 dollars) of the $212 million required to attain water pollution control standards.
2. The interest rate is 10 percent.
3. The growth rate is 5.8 percent.
4. The depreciation rate is 5 percent.
5. For down-time, the installation multiple is 1.5.

The combined annual costs per pound of both water pollution and air pollution abatement are as follows (dollars per pound):

	Low	Middle	High
1972	$ 0.002	$ 0.002	$ 0.004
1973	0.005	0.006	0.008
1974	0.013	0.014	0.019
1975	0.019	0.024	0.031
1976	0.020	0.025	0.032

Probable Trends in the Aluminum Market in the Absence of Pollution Controls

The aluminum market during the past two decades has been characterized by very high rate of growth of consumption while prices have remained fairly stable in real terms. The past two years, however, have been nearly disastrous for the producers. Shipments of mill products in the United States fell from 10.825 million tons in 1969 to 10.110 million tons in 1970. Although mill product shipments have increased in 1971 over their 1970 rates the total shipments in 1971 may not even equal the rate attained in 1969.

Capacity, on the other hand, has increased rapidly during the past several years. Noncommunist world reduction capacity increased from 7.8 million metric tons at the end of 1969 to 8.5 million tons at the end of 1970,

and is expected to increase even further to 9.7 million tons by the end of 1971, although some of the projected capacity expansion has been cancelled or postponed. As a result, operating rates have declined sharply. During 1970, U.S. producers were operating at about 92 percent of capacity; during the past several months the operating rate has fallen to about 85 percent.

Not surprisingly, the weak conditions in the aluminum market have resulted in a decline in transaction prices, although the U.S. list price has remained at $0.29 per pound. By the end of 1970 quantity discounts had reached as much as 12-14 percent of the list price. By May and June of 1971 these discounts had increased even further. Spot prices were reported to be as low as $0.23. There has reportedly been even a further erosion of prices in recent months.

The current weak conditions of the aluminum market are thus caused by the joint effects of a decline in demand stemming from the U.S. economic recession and a simultaneous increase in production capacity induced by the rapid rate of growth of demand during the 1960's. Both of these phenomena should be temporary; as the U.S. economy recovers, consumption of aluminum should resume its "normal" growth rate and the increase in sales of aluminum combined with the deceleration in the capacity growth rate should eliminate much of the current excess capacity.

In the absence of pollution controls, U.S. aluminum consumption over the next 5 to 10 years can probably be expected to grow at a rate of 6-10 percent per year, assuming that U.S. industrial production returns to its

former growth rate of 4-5 percent per year. Foreign consumption will probably grow somewhat faster than domestic consumption. The highest rates of growth in consumption will probably occur in consumer durables, building and construction, containers and packaging, and transportation.

The list price over this period will probably remain fairly stable in real terms (i.e., the money price will increase at about the rate of inflation). Transaction prices of aluminum, which are now as much as 25 percent below the list price, can be expected to approach the list price over the next two years as aluminum sales increase to rates commensurate with current and projected capacity, and thereafter will probably change more or less in proportion to changes in the list price.

Effects of Pollution Abatement Costs on the Aluminum Market

The effects of pollution abatement requirements on the aluminum market depend on the assumptions made about U.S. trade policies as well as on the assumptions made about the timing and the level of costs and about the pollution abatement requirements for other industries. The following analysis therefore first examines the effects on the aluminum market of the proposed abatement standards under a set of "neutral" assumptions -- i.e., that there is no import surcharge or equivalent revaluation of foreign currencies and that the timing and level of the abatement costs are as estimated by EPA. The effects of departures from these assumptions are then examined.

The effects of pollution controls on the aluminum market clearly depend on the assumptions made about controls on other industries that either compete with aluminum in its end use markets or sell goods and services to the aluminum market. For example, pollution controls on copper production may cause a significant increase in copper prices, thus offsetting some of the adverse effects of pollution controls on U.S. aluminum producers. Pollution controls will probably also result in some increase in the costs of power in aluminum production. To analyze the effects of pollution controls on the aluminum industry we will therefore first assume that controls are imposed only on the aluminum industry itself and then examine the effects on the results of controls on other industries.

Effects If Controls are Imposed Only on the Aluminum Market

The aluminum industry is currently in a depressed state, primarily because installed capacity is very large relative to the current demand for aluminum at relevant prices. This situation will almost certainly have been corrected by 1972 or 1973, as demand over this period will probably grow much more rapidly than capacity. The costs of pollution control will become sizeable in 1973 or 1974.

Throughout the history of the aluminum industry the principal U.S. producers have played dominant roles in determining the list price of aluminum. In an earlier econometric analysis of aluminum we have discovered a highly significant statistical correlation between U.S.

costs of production and the list price of aluminum. In the past, therefore, the U.S. producers have been able to pass along their costs of production to consumers, without suffering a significant loss in their market share -- of course, the increased prices cause a reduction in the total market for aluminum. This observation is supported by the fact that in the past price increases by U.S. producers have not resulted in a sharp increase in U.S. imports of aluminum.

Thus, assuming that by 1973 or 1974 capacity-utilization rates have recovered to normal levels, both our analysis and our econometric model of the aluminum market suggest that eventually the list price of aluminum will probably be increased more or less in proportion to the increase in production costs resulting from controls. Our econometric results indicate that most of the price increases will occur within a year after the cost increases, but there may be some lag in this adjustment. Unless the aluminum market is still in a state of extreme over capacity when the bulk of the control expenditures are made, transaction prices will increase along with the list price. As prices are increased, however, consumption will decline, which will result in some decline in transaction prices.

In the long run, lower capacity-utilization will cause capacity to grow more slowly. With normal growth in industrial demand, capacity-utilization will increase, inducing a rise in transaction prices. In the long-run equilibrium (5 to 10 years) both list and transaction prices will increase in near proportion to control costs,

consumption will decline below the rates it would otherwise attain, and capacity would adjust to the new consumption rates.

It is possible to make some rough quantitative calculations of these effects. In the solution to the CRA model, a permanent increase in costs of $0.01 per pound (about 4 percent of average costs of production) results in increases in transaction prices over a period of time by about 2 percent in the first year, rising to about 3 percent in the sixth year. The decline in consumption is .03 to .04 percent in the first year and rises to about 2 percent by the sixth year.

Using the CRA model the water and air pollution control costs described earlier in this chapter will have the following approximate percentage effects on consumption and transaction prices over the next 6 years:

Year	Control Costs ($/lb.)	Percentage Change in Consumption	Percentage Change in Transaction Prices
Low Cost Assumption:			
1972	$0.002	-.068	+0.430
1973	0.005	-.320	+1.185
1974	0.013	-.953	+3.060
1975	0.018	-1.973	+4.544
1976	0.020	-3.033	+5.217
1977	0.020	-3.701	+5.516
Middle Cost Assumption:			
1972	$0.002	-.068	+0.430
1973	0.007	-.388	+1.615
1974	0.014	-1.137	+3.585
1975	0.024	-2.388	+6.094
1976	0.025	-3.733	+6.656
1977	0.025	-4.606	+6.651

(continued on following page)

Year	Control Costs ($/lb.)	Percentage Change in Consumption	Percentage Change in Transaction Prices
High Cost Assumption:			
1972	$0.004	-.136	+ .800
1973	0.009	-.606	+2.155
1974	0.019	-1.593	+4.560
1975	0.030	-3.149	+7.428
1976	0.032	-4.840	+8.427
1977	0.032	-5.959	+8.217

Under the assumptions provided by the EPA estimates, the effects of the controls do not become substantial until the later years of the period. Under the middle cost assumption, as a result of the controls, U.S. consumption of aluminum in 1977 would be about 4.6 percent below what it otherwise would be and transaction prices would be about 6.5 percent above what they otherwise would be. Using the range of costs estimated by EPA, the effect on U.S. consumption is between 3.7 percent and 6.0 percent and the effect on transaction prices is between 5.3 percent and 8.2 percent.

It is also possible to provide a rough quantitative estimate of the absolute effects of the controls. In 1970 shipments to U.S. consumers of aluminum ingot and mill products were about 8.949 billion pounds. If we assume an illustrative average compound annual growth rate of 8 percent, by 1977 annual shipments would be about 15.3 billion pounds. Using the middle estimate of the control costs, as a result of the controls these shipments would be reduced by about 4.6 percent, or about 700 million pounds per year. Without pollution controls, the 1977 transaction price of aluminum would be about $0.29 per pound (in 1970 dollars). With pollution controls, this price would increase by about 6.7 percent, or by about $0.019 per pound.

In the very long run (say, over 10 years), transaction prices will increase by about the same percentage as costs. The higher prices of aluminum will, however, cause consumption to continue to decline below the rates it would otherwise attain (the reader will recall that the long-run elasticity of demand for aluminum is much greater than the short-run elasticity of demand).

For example, if we assume a growth rate of 8 percent per year, without controls U.S. aluminum consumption would be 22.5 billion pounds by 1982. If we assume that the control costs result in about a 10 percent increase in prices (approximately equal to the percentage increase in production costs caused by controls) and if we use our estimate of the long-run demand elasticity of -1.6, the controls will bring a long-run decline in annual consumption of 16 percent. By 1982 this reduction in consumption would equal 3.6 billion pounds.

Effects If Controls are Also Imposed on the Copper Industry

As discussed in Chapter 3, the long-run elasticity of demand for aluminum with respect to the price of copper is -0.357 -- that is, a 10 percent increase in the price of copper will in the long run lead to approximately a 3.6 percent increase in consumption of aluminum. The corresponding short-run (one year) elasticity is -0.037. Increases in copper costs and prices as a result of pollution controls will therefore have important effects on the aluminum market as well as on the copper market.

According to the estimates provided us by EPA, the total air and water pollution abatement costs for primary refined copper are as follows (dollars per pound of copper):

	Low	Middle	High
1972	$.003	$.003	$.003
1973	.004	.008	.010
1974	.016	.022	.027
1975	.029	.037	.047
1976	.033	.042	.053

A rough estimate of the effect of copper control costs on the aluminum market can be obtained by assuming that the increase in copper production costs will be reflected in an equal increase in copper prices. Using the middle cost estimate, this suggests that the copper price will increase by about $0.042 by 1976.

As the U.S. producers' price of copper is currently $0.54 per pound, an increase of $0.042 represents about an 8 percent increase in the copper price. We estimated earlier that the short-run and long-run elasticities of demand for aluminum with respect to the copper price are +0.037 and +0.357. Therefore, the copper price increase will cause about a 0.2 percent increase in aluminum consumption in the short run (one year) and about a 2.9 percent increase in aluminum consumption in the long run (5 to 10 years).

The copper price increases will therefore only offset a portion of the reduction in aluminum consumption caused by aluminum controls. The effect over the next five to six years would be negligible because the

increased costs to copper producers will not occur until the later portions of this period and because the short-run aluminum demand elasticity with respect to copper prices is very low. The effects over the next 10 years, however, would be noticeable. In our rough calculations, if controls are only imposed on aluminum, U.S. aluminum consumption in 1982 would decline from 22.5 to 18.9 billion pounds (or 16 percent). If controls on copper are also imposed, the net decline would be 13.1 percent (16 minus 2.9), or 2.9 billion pounds.

Effects of Controls If Power Generation is Also Controlled

It appears that controls on the costs of power in aluminum production will be only of secondary importance. According to our estimates, electric power and other fuel costs per pound of aluminum currently average about $0.03 to $0.04. As much of the power supplied to U.S. aluminum smelters is generated by hydroelectric sources, pollution controls on power generation are likely to affect only a portion of aluminum power costs. However, even under the extreme assumption that the power costs of all aluminum smelters increase by 10 percent, aluminum production costs will only increase by $0.003 to $0.004 per pound.

A cost increase of this magnitude is about one-sixth as great as the cost increases caused by pollution controls. Thus, all our estimates of the effects of control on aluminum may have to be adjusted upwards by as much as one-sixth to reflect the effects of controls on power generation.

Effects of Controls If Other Industries in Addition to Copper are Also Controlled

Aluminum competes with many other materials besides copper: steel, plastics, zinc die castings, wood, and titanium, for examples. The separate effects on aluminum consumption of changes in these prices are not statistically detectable. However, our estimates of aluminum demand elasticities are calculated using the price of aluminum relative to the wholesale durable price index. This index acts as a proxy for the broad range of materials with which aluminum competes.

Thus, if pollution controls increase the costs of production and therefore the prices of competing materials, the effects of the controls on aluminum would be significantly moderated. For three reasons, however, the adverse effects on the U.S. aluminum market would not be completely offset even if the market prices of competing materials increased by the same percentage as the aluminum price. First, it does not seem likely that the prices of all competing materials would increase as much as aluminum prices. Second, an across-the-board increase in the prices of all materials would probably result in a decline in the overall market for these materials. For example, even though the percentage increase in zinc production costs as a result of controls is at least as great as for aluminum, we conclude in a separate report that zinc prices will not increase in proportion to this cost increase. Third, the incentive to locate new smelters abroad would not be altered.

Effects of Controls on U.S. Aluminum Production

Even with controls, U.S. aluminum production will in the future probably grow at about the same rate as U.S. consumption, although this conclusion is by no means certain. As described in an earlier chapter, the principal foreign exporters of primary aluminum to the U.S. market have always exercised considerable restraint in their sales policies in the United States. The effect of the controls thus hinges on two issues: the effect of the controls on production from existing U.S. smelters and the effect of the controls on the location of new smelters built to serve the U.S. market in the future.

It does not appear likely that the control costs will force any existing smelters to be shut down, although it is possible that some of the oldest smelters nearing the end of their economic life might be phased out prematurely. The current investment in U.S. production facilities is a sunk cost. As long as the per pound control costs are greater than the difference between world market price adjusted for transportation and tariff costs and the variable production costs of existing smelters, it will pay to continue aluminum production at these smelters.

The average costs of production of an efficient smelter are currently about $0.25-0.26 per pound (assuming normal capacity utilization); average variable costs are about $0.18-0.19 and average fixed costs are about $0.07 per pound. The average market price of aluminum in the long run will not normally decline below $0.25-0.26 range

(although prices may decline below their level in times of severe over capacity). Therefore, the cost disadvantage to U.S. producers because of pollution controls would in general have to be at least $0.07 per pound before they would be induced to close existing smelters. If this production were to be replaced by foreign production, this figure would have to be several cents greater to account for transportation and tariffs.

As the costs of pollution controls at smelters are estimated to be $0.023 per pound, it will pay producers to install control equipment at most smelters rather than shut them down. A number of U.S. smelters, however, date back to World War II or earlier. It is conceivable that some of these smelters are nearing the end of their economic lives and will be closed down prematurely as a result of the controls. It is also possible that the technology of some of these smelters may be so outdated that the control technology developed for modern smelters simply cannot be applied. There is no way to resolve these issues without detailed information (of a type that is not publicly available) on individual smelters.

We can probably assume that production costs at new locations abroad are not appreciably greater than U.S. production costs exclusive of pollution controls (aluminum production is not labor intensive and the accessible sources of cheap power have already been exploited). As transportation plus tariff costs for importing aluminum from abroad are somewhat greater than $0.02 per pound, U.S. control costs of $0.023 may be just great enough to induce new smelters serving the U.S. market to be located

abroad. However, most other industrialized nations will probably also impose pollution controls. These controls may not be as stringent as those in the United States, but they will reduce the incentive to locate smelters abroad. In fact, even the expectation that controls may be imposed could discourage smelter construction in foreign countries. In addition, there is a strong possibility that increases in U.S. imports of aluminum could cause the U.S. tariff on primary aluminum to be increased. This possibility would also discourage smelter construction abroad.

If the controls do cause new smelters to be constructed abroad, the effects on the share of the U.S. market accounted for by U.S. production would not be felt for a number of years. U.S. smelters are currently operating at about 85 percent capacity and there will be no incentive to construct new smelters to serve the U.S. market for at least several years. In addition, capacity at existing smelters can be increased even further before new smelter capacity would be necessary.

To summarize, under the controls U.S. production will probably increase at about the same rate as U.S. consumption. There is a possibility that the controls may induce new smelters to be constructed abroad, but the effects of this would not be felt for at least five years after the controls are imposed.

Effects of Control Costs on U.S. Alumina and Bauxite Production

The costs of controlling water pollution at alumina

plants are estimated to be between $0.002 and $0.003 per pound of aluminum equivalent, or about $0.001 to $0.0015 per pound of alumina. Current production costs at alumina plants are about $0.036 per pound, of which average fixed costs are about $0.01 per pound and average variable costs are about $0.026 per pound.

As the control costs are only a function of the average capital costs required to build new alumina plants abroad, it is not likely that the controls will cause any existing plants to be shut down. There is already a strong tendency for new facilities to be located abroad, however, and this trend will be strengthened by the imposition of pollution controls in the United States.

U.S. bauxite production has declined slowly during the past several decades, and currently represents only a small percentage of U.S. bauxite consumption. Pollution control costs at bauxite mines are not expected to be significant.

Pollution controls will therefore probably have little effect on U.S. bauxite production. It is extremely unlikely that U.S. alumina production will actually decline as a result of the control costs, and the relatively small amount of U.S. produced bauxite will continue to have a market.

Effects of Controls on Employment

We concluded earlier that U.S. aluminum production will almost certainly not decline as a result of pollution controls, as the market for aluminum will continue

to grow and probably no domestic smelters will be closed as a result of the controls. Therefore, we would not expect any decline in employment in the aluminum industry below current levels as a result of the controls.

However, as a result of pollution controls employment will not increase as rapidly as it would if controls were not imposed. Using our earlier estimates, U.S. production in 1982 will be about 2.9 billion pounds less as a result of the controls (assuming that the controls do not cause new smelters to be located abroad). We estimate in Chapter 7 that on the average about 7.8 persons are employed per 1,000 tons of aluminum production. Rough calculations indicate, therefore, that by 1982, with controls, the industry will employ 11,310 fewer persons than if there were no controls.

The Net Costs to Producers of the Controls

The net cost to producers of these pollution controls can usefully be defined to be the net reduction in after-tax profits as a result of the controls. This net cost has two components: the reduced profits per unit on the aluminum that is actually sold and the profits foregone on sales that are lost as a result of the higher prices. In 1977 the first component would equal about $88 million (before taxes).[1] The second component

[1]Under these assumptions, 1977 shipments would be 14.6 billion pounds. As costs would increase by about $0.025 while transaction prices would only increase by about $0.019, the reduction in profits per pound would be about $0.006. The total reduction in profits would therefore be (14.6) x ($0.006) = $88 million.

would equal about $21 million.[1] The total before-tax cost to producers would therefore be somewhat greater than $100 million per year and assuming a 52 percent tax rate, the net after-tax cost would be somewhat greater than $50 million per year. The tax incentives discussed earlier would further reduce this net cost to a level below $50 million.

In the long run, transportation prices would probably rise somewhat, but consumption would continue below the rates it would otherwise attain. For example, by 1982 U.S. consumption would be approximately 2.9 billion pounds less than if there were no controls; this represents foregone before-tax profits of $87 million per year and foregone after-tax profits of less than $40 million per year.

To summarize, it appears that once the pollution controls are fully implemented the net after-tax costs of the controls to producers will be in the neighborhood of $40-60 million per year.

The Regional Impact of the Controls

The overall effect of the controls will be in retarding the rate of growth of the U.S. aluminum industry; the controls will probably not cause an actual decline in

---

[1]According to CRA calculations (in our March 1970 report to GSA), in recent years the averagemmarkup between average cost and list price is about $0.03 per pound. Assuming that without controls transaction prices by 1977 would be approximately equal to list prices, this represents the profits foregone per unit of sales. Total profits foregone are therefore about (700) x ($0.03) = $21 million.

aluminum production, consumption, or employment. The regional effects will be reflected in a slower rate of growth in investment in aluminum facilities than would otherwise occur. The input of this slower rate of growth will occur primarily in those regions that traditionally have accounted for most of U.S. aluminum production: the Pacific Northwest and a belt of land stretching from Southeast Texas to northern New York State, which includes Louisiana, Arkansas, the Ohio River Valley, and areas served by the Tennessee Valley Authority.

The Inputs of the Controls on Supplier and Consumer Industries

The major impact of the controls will clearly be on the domestic aluminum smelting industry. Producers of aluminum semifabricated products will also be adversely affected, as the total market for aluminum mill products will grow more slowly as a result of the controls. However, this adverse effect will probably consist of a slower rate of growth of sales than would otherwise occur, not in actual decline in sales. As these fabrications can probably pass on the increased prices of aluminum the effect on their profits will also consist of a slower rate of growth than would otherwise occur.

The remaining effects of the controls on suppliers and consumers are too diffuse to be isolated. The inputs to aluminum production are alumina, fluorides, carbon, operating and maintenance supplies, power, and labor.

We have already discussed the effects of the controls on aluminum and labor. Most aluminum producers manufacture their own fluorides. Consumption of power and carbon will grow more slowly as a result of the controls, but the aluminum industry consumes too small a percentage of total U.S. power and coal production for those effects to be noticeable.

Aluminum mill products are used in such a wide diversity of finished products that it is difficult to determine if any individual consuming sector will be severely damaged by slightly higher aluminum mill product prices. In most applications aluminum represents a small percentage of the total value of the product in question and in most applications aluminum has close substitutes, so we do not expect that any particular sector of the economy will be damaged by the controls on aluminum.

The Effects of the Controls On the U.S. Balance of Payments

As discussed in Chapter 7, the controls will probably not cause a substantial increase in U.S. imports of aluminum ingot from traditional suppliers. However, the controls could result in a decline in U.S. exports of ingot and mill products and an increase in U.S. imports of mill products.

The effects of the controls on this trade really hinge in large part on the location of new smelters. The existing smelters will continue in operation and their output will be marketed at competitive prices.

If the increased production costs do not cause new smelters to locate abroad, this will also be true of new smelter capacity.

Even if new smelters serving the U.S. market continue to be located in the United States, the increased costs of U.S. producers can be expected to result in a decline over time in U.S. exports of ingot and semifabricated products. The value of these exports is currently over $300 million per year.

The Effects of the Timing and Level of the Control Costs on the Aluminum Market

Our analysis has been made on the assumption that the timing and level of the control costs will be within the ranges estimated by EPA -- i.e., that the annual control costs will eventually reach $0.020 to $0.032 per pound and that the bulk of the expenditures will be made in 1974 and 1975.

The results of our analysis are quite sensitive to changes in these assumptions. For example, the aluminum market is currently in a state of extreme over capacity, especially in the United States, and the market will probably not be fully recovered until late 1972 or 1973. If the control expenditures have to be made earlier than assumed or if the market has not recovered by 1974, the impacts of the controls on the market may be much more severe than our analysis indicated. Although it is difficult to forecast exactly what will happen, it is possible that some firms will decide to shut down their smelters.

If the ultimate costs of the controls turn out to be less than we have assumed in the analysis, there will be little change in the nature of the results, although, of course, the magnitude of the impact will be proportionately less than we have indicated. On the other hand, if the ultimate costs turn out to be greater than we have assumed, the probability is quite high that there will be a diversion of new smelter construction from the United States to foreign countries. For there to be a significant possibility that existing smelters would be shut down, the control costs would have to be at least double the upper end of our assumed range.

The Effects of the 10 Percent Surcharge or Equivalent Currency Revaluation on the Results

The current 10 percent tariff surcharge on imports of aluminum almost exactly offsets the increase in production costs that would result from pollution costs -- that is, continuance of this surcharge will increase the costs of foreign producers selling in the United States by as much as pollution controls will increase the costs of U.S. producers. This will also be true if the current surcharge is replaced by equally large upward revaluations of the currencies of foreign nations exporting to the United States.

It is impossible to predict whether and for how long the current surcharge will be maintained. It does seem reasonably likely that if the surcharge is lifted

foreign currencies will be revalued, on balance, by as much as 10 percent. Thus, it seems quite probable that the surcharge or its equivalent will continue in the indefinite future.

Maintenance of the surcharge would have little effect on most of the results of our analysis, with the exception of our conclusions on balance of payments, imports, and the location of new smelters. As the surcharge or its equivalent will offset the increased costs of U.S. producers, we can fairly safely conclude if it is maintained that the incentives to locate smelter capacity abroad will be eliminated. The adverse effects of controls on the balance of payments would be substantially moderated, although we would still expect some erosion in U.S. exports of aluminum.

CRA
CHARLES RIVER ASSOCIATES INCORPORATED

This is one of four reports prepared by
Charles River Associates
for the
Council on Environmental Quality
on: Aluminum
Copper
Lead
Zinc